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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/988,685	11/20/2001	Yoshimi Shioya		9020

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EXAMINER
HOGANS, DAVID L

ART UNIT	PAPER NUMBER
2813	

DATE MAILED: 08/15/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/988,685	SHIOYA ET AL.	
	Examiner	Art Unit	
	David L. Hogans	2813	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *10 July 2003* .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1,3,4,6-8,12 and 26-28* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1,3,4,6-8,12 and 26-28* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *20 November 2001* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) *12* .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

This Office Action is in response to Amendment C filed on July 10, 2003.

Status of Claims

Claims 1, 3, 4, 6-8, 12 and 26-28 are pending. Claims 2, 5, 9-11 and 13-25 are cancelled.

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 1 and 6 are rejected under 35 U.S.C. 103(a) as being unpatentable over 6,383,925 to Ngo et al.

Claim 1

Ngo et al., in columns 4-6 lines 10-65, teaches exposing a copper surface to a nitrogen/ammonia plasma that removes the surface oxide as well as "nitrides" the copper layer into a diffusion prevention layer (noting that Ngo et al. teaches that nitrogen forms a thin transition layer between the barrier layer and the copper surface – See specifically column 4 lines 29-35). Although Ngo et al. is silent about converting the copper layer into a diffusion prevention layer the Examiner notes that the temperature, wattage, pressure, duration and flow rates employed by Ngo et al. during the nitrogen nitridation step are similar to the ones disclosed by the Applicant on page

10 and Table 1 of the specification. Therefore, similar process conditions must produce similar results (i.e. – nitridation).

Ngo et al. fails to explicitly teach a combination of steps in succession including ammonia treatment to clean the copper surface followed by a plasma treatment of the copper to form a copper diffusion barrier (noting Applicant's argument in Paper No. 15 on the top of page 9).

However, Claim 1 contains no language clearly denoting a sequence of steps. Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993). Furthermore, the Examiner notes that the specification contains no disclosure of either the critical nature of the claimed sequences or any unexpected results arising therefrom. Where patentability is said to be based upon particular chosen sequences or upon another variable recited in a claim, the Applicant must show that the chosen sequences are critical. *In re Woodruff*, 919 F.2d 1575, 1578 (Fed. Cir. 1990)

Therefore, in the absence of evidence to the contrary, the Examiner deems the disclosed processing steps of Ngo et al. to be equivalent to the claimed subject matter of Claim 1.

Claim 6

Incorporating all arguments of Claim 1 and noting that Ngo et al. teaches forming a silicon containing insulating film (40) on the copper layer after nitridation. See columns 4-6 lines 10-65.

3. Claim 4 is rejected under 35 U.S.C. 103(a) as being unpatentable over 6,383,925 to Ngo et al. in view of Simple, Reliable Cu/low-k Interconnect Integration Using Mechanically strong Low-k Dielectric Material: Silicon-oxycarbide to Furusawa et al. (June 2000).

Ngo et al., in columns 4-6 lines 10-65, teaches exposing a copper surface to a nitrogen/ammonia plasma that removes the surface oxide as well as "nitrides" the copper layer into a diffusion prevention layer (noting that Ngo et al. teaches that nitrogen forms a thin transition layer between the barrier layer and the copper surface – See specifically column 4 lines 29-35). Although Ngo et al. is silent about converting the copper layer into a diffusion prevention layer the Examiner notes that the temperature, wattage, pressure, duration and flow rates employed by Ngo et al. during the nitrogen nitridation step are similar to the ones disclosed by the Applicant on page 10 and Table 1 of the specification. Therefore, similar process conditions must produce similar results (i.e. – nitridation).

Ngo et al. teaches depositing a SiN film over the copper layer but fails to explicitly teach wherein a SiOC film is formed on the copper layer to prevent copper diffusion.

However, Furusawa et al., on pages 222-224, teaches forming SiOC over a copper layer.

It would have been obvious to one of ordinary skill in the art to modify Ngo et al. by incorporating the formation of a SiOC layer over a copper layer, as taught by Furusawa et al., to improve the mechanical strength of Cu/low-k interconnects and, more importantly, to reduce wiring capacitance by using a low-k dielectric (i.e. – SiOC). Since reduction in wiring capacitance is essential to improving operational speeds of ULSI devices, it would have been obvious to substitute a low-k dielectric to reduce capacitance effects.

4. Claim 7 is rejected under 35 U.S.C. 103(a) as being unpatentable over 6,383,925 to Ngo et al. in view of 6,150,270 to Matsuda et al.

Incorporating all arguments of Claims 1 and 6 and noting that Ngo et al. fails to explicitly teach exposing the silicon containing insulating film to a second nitrogen plasma.

However, Matsuda et al., in column 4 lines 52-65, teaches exposing a silicon film to a nitrogen plasma. Furthermore, Matsuda et al. teaches that the nitrogen plasma nitrides the silicon film into a silicon nitride film.

It would have been obvious to one of ordinary skill in the art to modify Ngo et al. by incorporating the exposure of a silicon film to a nitrogen plasma, as taught by Matsuda et al., to nitride the silicon film into a silicon nitride film that functions effectively as a barrier layer for prevention copper diffusion and oxidation.

5. Claim 8 is rejected under 35 U.S.C. 103(a) as being unpatentable over 6,383,925 to Ngo et al. in view of 6,174,810 to Islam et al.

Incorporating all arguments of Claims 1 and 6 and noting that Ngo et al. fails to explicitly teach forming an insulating layer over the silicon containing insulating film, forming a via hole through the insulating layer and the silicon containing insulating layer, burying a plug connected to the copper layer and forming an upper wiring layer connected to the plug.

However, Islam et al. in columns 5-7 lines 10-26 and Figures 1-7, teaches forming an insulating layer over the silicon containing insulating film, forming a via hole through the insulating layer and the silicon containing insulating layer, burying a plug

connected to the exposed copper layer and forming an upper wiring layer connected to the plug. Furthermore, Islam et al. teaches that one would do this to form a copper interconnect structure.

It would have been obvious to one of ordinary skill in the art to modify Ngo et al. by incorporating an insulating layer formed over the silicon containing insulating film, forming a via hole through the insulating layer and the silicon containing insulating layer, burying a plug connected to the exposed copper layer and forming an upper wiring layer connected to the plug, as taught by Islam et al., to form a copper interconnect structure.

6. Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over 6,383,925 to Ngo et al. in view of 6,174,810 to Islam et al. further in view of 6,277,733 to Smith.

Incorporating all arguments of Claims 1, 6 and 8 and noting that Ngo et al. and Islam et al. fail to explicitly teach wherein the insulating film is formed by FSG or porous silicon dioxide.

However, Smith, in column 3 lines 13-30, teaches a dielectric layer formed of FSG that is formed over a silicon containing barrier layer, wherein both layers are etched to expose a copper surface. Furthermore, Smith, teaches that FSG is a good dielectric layer because it has a low dielectric constant.

It would have been obvious to one of ordinary skill in the art to modify Ngo et al. and Islam et al. by incorporating a dielectric layer formed of FSG that is formed over a silicon containing barrier layer, wherein both layers are etched to expose a copper surface, as taught by Smith, to form a dielectric layer that has a low dielectric constant.

7. Claims 26 and 3 are rejected under 35 U.S.C. 103(a) as being unpatentable over 6,383,925 to Ngo et al. in view of 6,251,771 to Smith et al.

Claims 26 and 3

Incorporating all arguments of Claim 1 and noting that Ngo et al., in columns 4-6 lines 10-65, teaches exposing a copper surface to a nitrogen/ammonia plasma that removes the surface oxide as well as "nitrides" the copper layer into a diffusion prevention layer (noting that Ngo et al. teaches that nitrogen forms a thin transition layer between the barrier layer and the copper surface – See specifically column 4 lines 29-35). Although Ngo et al. is silent about converting the copper layer into a diffusion prevention layer the Examiner notes that the temperature, wattage, pressure, duration and flow rates employed by Ngo et al. during the nitrogen nitridation step are similar to the ones disclosed by the Applicant on page 10 and Table 1 of the specification. Therefore, similar process conditions must produce similar results (i.e. – nitridation).

Ngo et al. fails to explicitly teach adding a hydrocarbon (i.e. – methane or acetylene) gas to the ammonia/nitrogen mixture when nitriding the copper layer.

However, Smith et al., in column 3 lines 45-56) teaches exposing a copper surface to plasma consisting of nitrogen and methane.

It would have been obvious to one of ordinary skill in the art to modify Ngo et al. by incorporating exposing a copper surface to plasma consisting of nitrogen and methane, as taught by Smith et al., to passivate the surface of the copper layer to prevent deterioration of electronic properties.

8. Claim 27 is rejected under 35 U.S.C. 103(a) as being unpatentable over 6,136,680 to Lai et al. in view of Simple, Reliable Cu/low-k Interconnect Integration Using Mechanically strong Low-k Dielectric Material: Silicon-oxycarbide to Furusawa et al. (June 2000).

Lai et al., in columns 5-9 lines 55-14 and Figures 1-7, teaches nitriding a surface of copper with a plasma comprised of nitrogen or nitrous oxide, to form a copper diffusion prevention layer, and then forming a SiN or SiON or SiO film over the nitrided copper layer. The examiner notes that the processing conditions for nitridation employed by Lai et al. fall within the prescribed ranges disclosed by Applicant on page 10 and Table 1 of the specification.

Lai et al. fails to explicitly teach wherein a SiOC layer is formed over the nitrided copper layer.

However, Furusawa et al., on pages 222-224, teaches forming SiOC over a copper layer.

It would have been obvious to one of ordinary skill in the art to modify Lai et al. by incorporating the formation of a SiOC layer over a copper layer, as taught by Furusawa et al., to improve the mechanical strength of Cu/low-k interconnects and, more importantly, to reduce wiring capacitance by using a low-k dielectric (i.e. – SiOC). Since reduction in wiring capacitance is essential to improving operational speeds of ULSI devices, it would have been obvious to substitute a low-k dielectric to reduce capacitance effects.

9. Claim 28 is rejected under 35 U.S.C. 103(a) as being unpatentable over 6,136,680 to Lai et al. in view of 6,251,771 to Smith et al. in view of Simple, Reliable Cu/low-k Interconnect Integration Using Mechanically strong Low-k Dielectric Material: Silicon-oxycarbide to Furusawa et al. (June 2000).

Lai et al., in columns 5-9 lines 55-14 and Figures 1-7, teaches nitriding a surface of copper with a plasma comprised of nitrogen or nitrous oxide, to form a copper

diffusion prevention layer, and then forming a SiN or SiON or SiO film over the nitrided copper layer. The examiner notes that the processing conditions for nitridation employed by Lai et al. fall within the prescribed ranges disclosed by Applicant on page 10 and Table 1 of the specification.

Lai et al. fails to explicitly teach wherein a hydrocarbon gas is added to the nitrogen or nitrous oxide plasma or wherein a SiOC layer is formed over the nitrided copper layer.

However, Smith et al., in column 3 lines 45-56, teaches subjecting a copper layer to a nitrogen/methane plasma. Furthermore, Furusawa et al., on pages 222-224, teaches forming SiOC over a copper layer.

It would have been obvious to one of ordinary skill in the art to modify Lai et al. by incorporating exposing a copper surface to plasma consisting of nitrogen and methane, as taught by Smith et al., to passivate the surface of the copper layer to prevent deterioration of electronic properties. Furthermore, it would have been obvious to one of ordinary skill in the art to modify Lai et al. by incorporating the formation of a SiOC layer over a copper layer, as taught by Furusawa et al., to improve the mechanical strength of Cu/low-k interconnects and, more importantly, to reduce wiring capacitance by using a low-k dielectric (i.e. – SiOC). Since reduction in wiring

capacitance is essential to improving operational speeds of ULSI devices, it would have been obvious to substitute a low-k dielectric to reduce capacitance effects.

Response to Arguments

10. Applicant's arguments with respect to claims 1, 3, 4, 6-8, 12 and 26 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

11. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

US 6,114,238 to Liao teaches nitridation of a copper surface via a nitrogen plasma.

US 6,576,980 to Shao et al. teaches forming a SiOC layer over a copper layer as a viable low-k material for advanced integrated circuit technology.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to David L. Hogans whose telephone number is (703) 305-3361. The examiner can normally be reached on M-F (7:30-4:30).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead Jr. can be reached on (703) 308-4940. The fax phone numbers for the organization where this application or proceeding is assigned are (703)

308-7722 for regular communications and (703) 308-7724 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-1782.

dh
August 6, 2003

SUPERVISORY PRIMARY EXAMINER
TECHNOLOGY CENTER 2800